A History of G. E. Belliss & Company and Belliss & Morcom Limited

BY

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The story which I am to relate to you today is, I think, one of the outstanding mechanical engineering developments of the last 100 years or so, even though one must admit that it took place in a time of tremendous industrial activity when such happenings could be expected. It actually began with two Shropshire brothers, Richard and Francis Bach, whose home was at Rowton; Richard supplied most of the finance and Francis the engineering. These two men took a lease of premises in Broad Street, Islington, Birmingham (Plate III (*top left*)), in 1852 where they established a general engineering business to make steam engines, water pumps, agricultural machinery and, in fact, almost anything mechanical such as was made at that time by many similar small engineering works to be found up and down the country.

Although records do not reveal any family acquaintance the fact that John Belliss lived at Roden in Shropshire, only a few miles from the Bach Bros until 1826, doubtless led to his youngest son George Edward, who was born in Birmingham on 30 August 1838, being apprenticed to the Bach brothers on 18 January 1855, at the age of 16 years 5 months, for a term of four years seven months, which brought him almost to his 21st birthday, at a fee of £99 19s. This indenture of apprenticeship, which is preserved in the archives of Belliss & Morcom Ltd., was drawn in very similar terms to those in general use today.

Most business men in the middle 1800s only had time to write essential records and correspondence and did not preserve for posterity anything which was not necessary to them for the continuity of their business. Thus the records from which this Paper has been compiled not being very numerous, the Author has had to resort to deduction. Even allowing for the vagaries of the human memory, I can assure you that there is sufficient substance in these records for an authentic history.

It is recorded that young George Edward Belliss showed during his apprenticeship much dexterity of hand and, in spite of the sparcity of technical books at that time, acquired a considerable knowledge of the strength of materials; even before his term expired he was designing machinery for his masters. At the conclusion of his apprenticeship Belliss continued with Bach & Co. and, although history does not so relate, he undoubtedly took a major role in running and developing the business. Seven years later, in December 1866, at the age of 28, he founded a partnership with another young engineer, Joseph John Seekings, and together they took over the business in which Belliss had learned his trade, under the name of Belliss & Seekings.

Up to this time nothing very extraordinary had been made by the Company, as is evidenced by (Plate III (*bottom left*)), which depicts the type of steam engine then being constructed. The price of a complete engine and boiler is interesting: one of 10 h.p. could be purchased for £180, and although no value of turnover is known the partners netted £150, £800 and £900 in successive years. Though indicative of the growth of the business, these profit figures were small by comparison with those achieved by R. Bach & Co. This may well have been the reason for introducing travelling portable steam engines, flour and mortar mills, circular saw benches, and contractors' locomotives (Plate III (*bottom right*)). One of these locomotives built in 1874 was supplied to Pike Bros., Fayle & Co. Ltd.,

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of Wareham in Dorset; where it was employed on a 3 ft. gauge railway. It is unique for this gauge in that it has three pairs of driving wheels and would be designated a 0–6–0 tank type. Some of its other special features are that it has outside Stephenson valve gear, that the cylinders, wheels and motion work are enclosed by a skirting fixed on the frame and that the water tanks are housed below boiler level on each side, thus reducing the centre of gravity and making for greater stability on the track. This locomotive was reconditioned by Stephen Lewis of Poole in 1880 and partly reconstructed in 1936 by Peckett & Son of Bristol, and did continuous service until 1955, when rail transport was replaced by motor vehicles. It was presented to the City of Birmingham Museum of Science and Industry by the contractors—Abelson—at the instigation of the Birmingham Locomotive Club, and the Author is indebted to the *Narrow Gauge Railway Society Handbook No. 1* for much of this information.

About 1863 Belliss became associated with John Samuel White, of Cowes, in the building and equipping of steam launches. In 1864 Belliss conceived the idea of increasing the power weight ratio of reciprocating steam engines by increasing the rate of revolution, and so it was that he developed, from his own designs, launch machinery for steam boats of about half the weight which had previously been in use. This development, together with the boat-building association with White, rather naturally turned the minds of Belliss and White towards the Royal Navy. This development was not in accordance with Seekings's beliefs: for Seekings was a member of one of the many renowned Quaker families of the Birmingham district and his religious persuasion precluded him from partaking in anything associated with the endangering of human life. So the partnership was terminated at the end of 1865, and Belliss became the sole proprietor working under the style of G. E. Belliss & Co.

I shall digress a little at this point into the realm of Seekings, since what happened subsequently is complementary to the whole story. Seekings went to Gloucester and there, with the financial aid of a gentleman of like religious persuasian of the name of Cadbury, started an agricultural and general engineering works on the quay by the River Severn. Whilst Seekings was not prepared to continue in a business concerned with fighting ships he was, nevertheless, not averse to making machinery for the brewing industry, and it appears, from the slender records which are available, that he satisfied his conscience in this respect by giving a considerable portion of his profits to a Temperance Society. Seekings eventually took a partner of the name of William Sisson, and when Seekings died a few years later the style of the Company was changed to W. Sisson & Co. Ltd. Under Sisson the Company quickly established itself in the realm of steam engines, particularly for launches, and later engines of the enclosed forced lubricated type for driving electric generators as well as making many other types of machinery. Today this Company is a wholly-owned Subsidiary of Belliss & Morcom Ltd., the successor of the company with which Seekings was formerly associated.

1870 found the engineering industry in a very flourishing condition which brought about a considerable shortage of skilled labour. This resulted, naturally, in much poaching by the employers, a position of which the men were not slow to take advantage. Before another year had passed the situation had become so intolerable that in October 1871 29 employers in Birmingham formed a body called "The Society of Master Engineers, Machinists and Ironfounders," which was the forerunner of the Birmingham Employers Association. This was the first body of its kind to be set up in this country. The first Chairman was Joseph Taylor of Taylor & Challen; the Honorary Secretary and Treasurer was G. E. Belliss. The purpose of this Society was to stop the poaching and thereby control rates of pay. The employees got wind of what was going on and promptly put demands to the employers for better wages and working conditions. Taylor and Belliss were empowered to negotiate and settle with the men, since this dispute had assumed major proportions and threatened the future of the industry. The outcome was the 54-hour week, with overtime obligatory as required, to be paid for at the new rate of $1\frac{1}{2}$ times the ordinary rate. These terms proved acceptable to the men, and the industry once again settled down to a reign of peace and expansion. The Minute Book of these

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Employers' meetings is still in the possession of the Company, and takes the form of a small black-backed notebook in which is written, in longhand, the various decisions reached.

Following the settlement of this labour dispute business was so brisk that it became necessary for the Company to move into new premises in Ledsam Street; by the end of 1872 the number of employees had risen to 100. The next 20 years saw tremendous developments in the construction of ships and their propulsion by steam-driven machinery. Belliss's higher speed propulsion engines and appropriate boilers were first adopted by the Royal Navy for wooden hull pinnaces. These single- and two-cylinder engines used a boiler pressure of 70 lb. per sq. in. and were coal-fired.

Torpedo boats for the Royal Navy using fire-tube boilers and light-weight engines became formidable weapons of war, and having first been supplied with considerable success to the Royal Navy were subsequently supplied to the navies of the world. All this development was carried out by Belliss in association with Samuel White. In the early years this association was conducted entirely by correspondence, but on one occasion Belliss decided to visit White in order to discuss some technicality personally with him. Finding him difficult to negotiate with, Belliss came away without having settled the business, deciding that it would be better to do so by letter. A second meeting took place shortly afterwards; but so determined were the two men in the opinions which they held that it was obvious that verbal discussion was more likely to bring about the end of the association between them rather than develop it. They mutually decided, to the subsequent advantage not only of themselves but many other people, never to meet again. Throughout the whole of their long association they only met on these two occasions, but remained the closest of friends right through to the end of the century.

Mention of a torpedo boat naturally brings to mind the Whitehead torpedo, the engines for which were made by Belliss, who also constructed high pressure compressors for charging the tubes. These compressors were capable of delivery pressures up to 2,000 lb. per sq. in.; but for this particular service were usually made to work at about 1,200 lb, per sq. in.

During this association with the sea and the Royal Navy Belliss naturally became acquainted with the Royal Dockyards, and with Alfred Morcom, who at the material time was Chief Engineer at Sheerness and prior to this had been at Portsmouth. Alfred Morcom was born in the Isle of Man of Cornish parents and persisted a true Cornishman throughout his days. He was undoubtedly in line for higher posts with the Admiralty, but Belliss fortunately persuaded him to give up these prospects. In 1884 they formed a partnership, still trading under the style of G. E. Belliss & Co.

About this same time the electric dynamo had started to come into its own for lighting purposes and one of its early uses was for ships. Many engines, mostly compound and of the open type, were constructed with drip lubrication; but the disadvantage of this at high rates of revolution soon became evident. Protective plates were fixed at the front and back of the engine to mitigate the nuisance of oil splash.

Not long after Morcom had joined Belliss he introduced a young seagoing engineer to the Company whom he had known when he was at Portsmouth. It was thus that Albert Charles Pain, the son of a Hampshire farmer, joined the Company as Chief Draughtsman. He too, had experienced the mess caused by oil being splashed about, but had also noted the fact, demonstrated by a fellow engineer at sea, that a heavy knock in a bottom-end bearing could be cured temporarily by pouring oil down the drip-feed lubrication pipe, thus filling the clearance with oil. In 1891 the first totally-enclosed force-lubricated engine was constructed under cover of a patent, which was allowed to lapse 12 years later, for the improvement of this form of lubrication. Besides the enclosure of the crankcase the other outstanding feature of this engine was the valveless oil pump (Plate III (*top right*)); together these two features were to herald the dawn of an almost limitless future.

No. 1 engine of this type (shown in Plate IV (*a*)) did almost continuous service for about 30 years. She was finally retired in the 1930s and now stands amongst the exhibits of motive power development

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at the Science Museum, South Kensington, a lasting monument to the inventive genius and ingenuity of the three men principally concerned.

During all this excitement and activity the Admiralty were developing a new type of fighting ship, the steel-hulled torpedo-boat destroyer. Such a ship was H.M.S. *Swordfish*, which was propelled through twin screws by two four-cylinder triple expansion engines each of about 2,000 i.h.p. These engines each had cylinders of 18¾ in. h.p., 27¼ in. i.p. and two 28 in. l.p. stroking 1 ft. 6 in. at 175 r.p.m. The steam was supplied by eight Yarrow-type water-tubular boilers at 200 lb. per sq. in. and the engines exhausted to a vacuum of 26 in. of mercury, giving the ship a speed of 21 knots. There were also, among the auxiliaries, two single-cylinder air compressors for charging and firing torpedos, four engines for driving forced-draught fans, and one compound tandem engine for driving a dynamo, all made by G. E. Belliss & Co.

It took about five years for the advantages of the enclosed forced-lubricated engine to win appreciation, but when they did it came with a vengeance, and soon, based on ships' engine experience, a range of one, two and three crank engines with single and tandem compound cylinders were developed. The demand for these engines quickly outstripped the supply, but this did not deter the engineering genius of the partners and staff from effecting improvements. At the outset the lubricating oil consumption was heavy as the cylinder being bolted directly to the crankcase permitted oil to be drawn through the piston rod packing into the cylinder. This also produced undesirable contamination of the exhaust steam passed to a condenser and thence to the boiler feed water tank. This was overcome by inserting a distance piece slightly longer than the stroke between cylinder and crankcase, and applying scraper glands.

All this activity required more finance than the partners could themselves supply, so in 1893 they decided to share the burden with others and became a private limited liability company.

The central-valve compound two-crank engine was the next improvement, and this held sway for a number of years. But the demand for larger engines, particularly by municipalities and electric light companies was becoming overwhelming and, just before the turn of the century, it was necessary to recruit more design staff and embark on works extensions. Thus, in order to assist with the triple expansion range of engines (Plate IV (*b*)), the largest of which were supplied to Birmingham Corporation, Alexander Jude, of whom more later, was imported from the north-east coast, with his knowledge and experience of large reciprocating machinery for ships. Eventually the range of these steam engines covered 5 to 2,500 b.h.p., 1,500 to 150 r.p.m. and steam pressures up to 350 lb. per sq. in., with superheat to a total temperature of around 700° F.

The system of making use of the latent heat of steam, instead of wasting it in a condenser, by letting the engine exhaust against a positive pressure into a process steam main, was first introduced in 1900, thus raising the overall thermal efficiency of the plant raising and using steam to as high as 70 per cent.

In 1899 when contracts were placed for a large extension to the works to be built in Icknield Square, delivery times were so far behind promises that a night shift was instituted for the first time and continued for two years until the new works was in production.

Once again the demand for finance outstripped the resources of the partners and their associates and they decided in 1899 to form Belliss & Morcom Ltd. with a new issue of capital to take over G. E. Belliss & Co. Ltd. A Birmingham Stock Exchange quotation for the preference shares and debentures was obtained in 1900, but the ordinary shares were held entirely by the former partners and their nominees. So brisk was business in these early days of the present Company that within five years most of the debentures had been redeemed and surplus profits were being invested.

All these years of intense activity started to take their toll of G. E. Belliss, and it is recorded in the Directors' Minutes of 1900/1 that he was granted six months leave.

We also find during these four years surrounding the turn of the century that the Company in quick succession became a member of the Birmingham Chamber of Commerce, set up a Pension and

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Benevolent Fund for the benefit of employees and their dependants, became a subscribing member of the Foremen's Mutual Benefit Society, made a gift to Birmingham University of a 100 h.p. engine and instituted prizes for their apprentices. Up to this time all Board records had been made in longhand, but now and thereafter they were to be typed.

With the continued growth of the Company and illness of the Chairman, it became abundantly clear that the managing director and general manager alone could not perform all the functions of management, so in its wisdom the Board decided to set up three committees to advise them on financial matters and internal and external affairs, thus inviting, by this delegation of duties, the co-operation of their principal officers.

Then in 1902 quite unexpectedly there came a period of slackness in general business activity, but this seems to have spurred the Company on to greater efforts to develop new products. Mr. Jude, whom I have already mentioned, always had a liking for things which went round and round instead of up and down, and he prevailed upon Morcom to look at his design of a turbine which he had prepared in his own spare time, and which he thought might be of interest to the Company. He was not only encouraged in his ideas, but he was permitted to do his design development in the Company's time; albeit much to the dislike of Mr. A. C. Pain, who on one occasion even expressed the opinion that any machine with such an appallingly low efficiency could only be something of passing fancy. To his credit, and to the credit of some other members of the staff of the Company who held similar views, let it be recorded that in due time they changed their minds and embraced this new product whole-heartedly. After a series of experiments which were carried out on the already well-known drum-type of rotor machine the first commercially successful one was completed in 1906. Up to this time some 16 patents had been granted and in all over 20 were obtained, mostly concerned with the disc-type rotor and the methods of manufacturing and securing blades. In September 1906 Mr. Jude's classic book *The Theory of the Steam Turbine* was published.

Parallel with this design of a turbine that of a gas engine was put in hand to meet the ever-increasing competition from this comparatively efficient prime mover. But it was not proceeded with, no doubt on account of the revived demand for steam engines and the great interest being shown in the exhaust steam turbine.

Belliss's earlier illness had unfortunately left its permanent mark, and after a further spell of leave of absence he resigned both as Chairman and Director in March 1904, thereafter taking no further active part in the business. He retired to Milford-on-Sea where he died in February 1909; "a revered founder and a tried and trusted leader." George E. Belliss had many interests besides his business, the chief of which was most certainly the Church of England, for he not only took an active part in corporate worship, but made considerable financial contributions to the maintenance of St. Barnabas in Ladywood and the building of two new churches, and paid two visits to Palestine and on one occasion included Egypt. He also had a quite commendable collection of pictures, some of which were given to the Birmingham Art Gallery when he left "The Dell" at Kings Norton. He entertained on quite a considerable scale, and much enjoyed both this and the musical evenings for which his household became renowned amongst his relations and friends.

His former partner and friend of the last 20 years, Alfred Morcom, suceeded him as Chairman; but within a few months he too, was taken seriously ill and died in October 1905; "a loss to the engineering profession, he was conspicuous for his inventive genius, indefatigable activity in debate and genial nature." Anyone who worked with him could not help but be influenced by his great strength of character and devotion to duty. He was a "born" engineer and had that rare quality of being able to view a drawing and make freehand alterations which invariably proved to be right when stress calculations had been made.

The Company thus suffered the loss, within a space of two years, of two of the outstanding engineers

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of their time. But the tide of development continued to flow with the energy which these two men had imparted to their successors, and early in 1905 an agreement was signed with Mr. Docker, of Metropolitan Amalgamated Railway Carriage & Wagon Co. Ltd. for the design, manufacture and test of a steam passenger road vehicle. A number of patents mostly concerned with oil burners, transmission and hydraulic brakes were obtained in the succeeding years, and by late 1906 the first, and I believe only, vehicle was on road test. Very few records of this project were preserved because, when a decision was taken to concentrate effort on those products most likely to succeed, this passenger bus lacked commercial support, and most of the technical papers on it were then destroyed. I have, nevertheless, been able to discover that it was lent to the London & General Omnibus Company for exhaustive road trials which covered 15,000 miles and were successfully concluded in 1908. It had a Clarkson boiler which, using paraffin as fuel, supplied steam to a single-acting engine at 350 lb. per sq. in. and 650–700° F. total temperature. Its water consumption was 5 gallons for 40 miles. There was much competition in this steam bus business, the most severe coming from Clarkson & Teme Valley, and, of course, from the many versions of those driven by the petrol engine. Whilst the selling price at £700 for the steam vehicle was considerably less, by about £150, than that of the petrol version, and its cost of operation 8·5d. per mile compared with 14·37d., it finally lost out due to the essential materials for flash temperatures in the boiler not then being available.

George E. Belliss was ever mindful of the need to train the engineers of the future, and his private letter-book has records of indentures of apprenticeship being signed by him in the middle 1870s. This was continued with equal energy when Alfred Morcom joined him and, in fact, the new partnership took on two apprentices in their first year, 1884. Commercial apprenticeship was added in 1903 and the first sponsorship to a University, Birmingham, took place in 1905.

What I have already related of developments in the first decade of this century is by no means all. A prototype Admiralty design oil engine was built for service with a dynamo for shipboard lighting, and the purchase of Wade & Jones Ltd., together with their patents and manufacturing rights of high-speed oil engines and paraffin carburettors, led to the supplying of many paraffin engine dynamo sets, complete with storage batteries, for country houses and the like in remote districts where even then gas was not available. The fierce competition in efficiency brought about a number of inventions and improvements, such as the patenting and development of the V-type compound steam engine, whereby each valve could be set independently compared with the compromise settings previously dictated by the central valve engine. Steam condensers of both the kinetic jet and surface types were patented and developed. The firm had themselves to blend the oil for use in enclosed force-lubricated machinery, as a suitable grade was not procurable from the oil companies. An air compressor was developed, based on the frame and motion work of the well-tried steam engine using the patent Hoebiger & Rogler plate valves, for which a licence was taken to manufacture and sell. This two-stage-double-acting design of machine quickly established itself for reliability and efficiency and was the forerunner of many similar machines made throughout the world. It was first constructed about 1908 to be driven by electric motors at constant speed with on, off inlet control followed closely by the adaptation of the cylinders for tandem mounting on a steam engine to which was fitted a patent air-actuated variable speed governor. These compressors were made in a range of sizes to deliver between 50 and 6,500 cu. ft. of free air a minute up to 120 lb. per sq. in. pressure. Even in those early days isothermal efficiencies up to 72 per cent. were being obtained with the larger machines. Many variations of this original two-stage theme brought three-stage machines for higher pressures and still more of four and six stages of compression giving up to 7,000 lb. per sq. in. delivery pressure for gases as well as air.

The firm extended their manufacturing premises, this time at Rotten Park Street, with the payroll rising to over 1,000 men. They appointed agents throughout the world by whose help 75 per cent. of sales were exported. They formed a recreation club and rented a ground for the enjoyment of employees.

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All this development cost a great deal of money and it is computed that over a period of some 20 years upwards of £40,000 was involved in developing 106 patents, which cost £2,800 in fees.

Having developed the steam engine to an eminent position and the turbine to a considerable degree of perfection, it was not surprising that attention was now turned to a somewhat less-developed prime mover—the diesel engine. A design of diesel oil engine of the air injection type had, in fact, been in slow development for some years, but in 1914 it was decided to take more positive action by the appointment of P. A. Holliday as diesel engineer and designer. Within 18 months a new design of open "A" frame engine (Plate IV (*c*)) had completed its trials, but for the duration of the first World War no more commercial developments took place, the Company being designated a controlled establishment by the Ministry of Munitions of War. Other than to record that during this period all production was for the war effort, the only matters of note were the occupation of a new block of offices started in 1914 and the building of the only horizontal gas engine under Fullagar patents for driving a 1,250 Kw. electric generator.

Shortly after the conclusion of hostilities the 47-hour week was introduced, which brought great benefits to the general body of the working population. As soon as war contracts had been cleared out of the way the Company took up its normal commercial activities and proceeded again in the development of its diesel oil engines assisted considerably by a contract to overhaul and adapt ten German ex-submarine engines for the electric generating station at Southend-on-Sea. They also obtained a considerable contract from the French Government to supply air compressors for the re-equipment of the invaded mines of Northern France, for which a licence was arranged with Société Rateau to make half of those required. Turbine design and size were also advancing, and one of the first orders for a 10,000 Kw. direct-coupled 3,000 r.p.m. turbo generator set was obtained from the West Ham Corporation. Together with this, some earlier patents and experiments on turbo compressors were again taken up, and the cellular-cooled design of machine was developed with considerable success.

At one time or another through the years the firm designed and built turbines of almost every description. The earliest were for operation by high pressure steam at 200 lb. per sq. in. exhausting to a condenser. Then came the low pressure machine taking steam at about atmospheric pressure from a reciprocating engine and again exhausting to a condenser. This was quickly followed by the mixed pressure type, being a combination of the first two with a patent governor gear for the simultaneous control of both high and low pressure steam.

Gradually both steam pressures and temperatures, also speeds of revolution were increased in the interests of greater efficiency and a better power/weight ratio; this brought about the establishment of reduction geared units. Perhaps the most interesting of these latter were the completely self-contained portable sets mounted on crossbraced girders (Plate V (*a*)). In these both circulating and extraction water pumps were mechanically driven through gearing from the turbine shaft.

Unfortunately, the labour troubles of 1920 and 1922 upset the progress of the engineering industry very considerably but this was soon forgotten in the enthusiasm created by the great Wembley Exhibition of 1924 in which the Company took an active part, both as exhibitors and by lending a turbine for the Exhibition Power Station.

As a result of earlier experiences, the first totally enclosed air injection diesel engine to be designed and built in this country was completed in 1927 (see Plate IV (*d*)) and from this came the airless or solid injection development to which was added successively in later years pressure charging and high pressure charging increasing the output of a given frame by 50 and 100 per cent. respectively.

The dual fuel engine using gas as its main fuel with 10 per cent. of its normal diesel oil for ignition purposes was added to this type of prime mover in subsequent years being particularly suitable for use in gas works for driving compressors at variable speeds by means of a gas pressure controlled patent governor.

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Shortly before the second World War a boiler was installed working at 500 lb. per sq. in. pressure mainly for the purpose of testing turbines, but this was soon to prove to be too low a figure for further development, particularly of the "Topper" type turbine. An initial order was obtained for a machine of this type to work at pressures and temperatures of 900 lb. per sq. in and 900° F.

Much work was done in the middle 1930s on the high pressure compression of gases, particularly applicable to gas traction which was used with considerable success and a useful degree of economy both on refuse-collection vehicles and motor omnibuses just prior to and during the second World War.

Education and training have always held a high place in the Company's considerations, and they have from time to time not only made considerable contributions to the funds of educational establishments but have made special designs of, for instance, a turbine to be used for instructional purposes at Universities and Technical Colleges. Their steam engines and compressors have also been adapted for this purpose. Examples of these are shown in Plate V (*b*) and (*c*).

In making my acknowledgments to Belliss & Morcom Ltd., who have allowed me to use the records in their possession, I must emphasise that these comprise leases of premises and land, agreements, small personal notebooks, private account and correspondence books, all hand-written, prior to the formation of the present Company in 1899. Thereafter I have had access to Minute books and technical data. I can only hope that you have been interested in the history I have presented to you today, compiled from this regrettably somewhat slender information.

DISCUSSION

Mr. R. H. CLARK asked Mr. Belliss if the Bachs mentioned in his Paper were any relation to the family of the same name noted by Mr. J. S. Allen in the previous month's paper on the 1712 Newcomen engine near Dudley? Incidentally in Welsh, *bach* meant *little.*

Mr. Clark said he was particularly interested in what Mr. Belliss had told about the early self-moving road engine by Richard Bach because this was the first of the Boydell engines constructed. Mr. Bach in a letter to *The Engineer* stated he found the perpendicular distance from the pitch line of the gear on the Boydell patent wheel to the centre line of the crankshaft of the standard portable engine he was using as a basis was exactly 6 in. Therefore he was able to fit a pinion of 12 in. pitch circle diameter as used on one of his agricultural machines mentioned by Mr. Belliss. The Boydell patent wheels were supplied ex-Boydell & Glasier and made according to Mr. James Boydell's patents in 1845 and 1854.[1]

Concerning the two small locomotives by Belliss & Seekings, Mr. Clark produced a drawing of the 0–4–0 which showed it to have a jackshaft with a crank on each end to which were fitted the centres of the coupling rods. The speaker asked if this arrangement had any connection with the Box patent jackshaft as fitted to some Fowell and Robey traction engines? This Belliss & Seekings locomotive had inside cylinders. Mr. Clark thought that by using a jackshaft the accessibility characteristic of outside cylinders and motion was partly attained without actually exposing the cylinder to the risk of damage otherwise likely in contractor's locomotives. At this period (1862) the firm's London agent was R. Winder, 18 Abingdon Street, Westminster.

Although he could not add to Mr. Belliss's information on the steam omnibus Mr. Clark said there were references to it in early volumes of *Motor Traction.*

In addition to the drawing of the Belliss & Seekings locomotive Mr. Clark showed one of the Bach-Boydell road engine, and these two he asked Mr. Belliss to accept with his compliments.

[1] An outline of this first Bach-Boydell engine will be found in R. H. Clark, *Development of the English Traction Engine*, Fig. 74.

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Mr. Rex Wailes said he felt sure there must be a tenuous connection between all the Baches, if it could be traced. While on the subject of names, William Sisson (an early Member) had said in effect at a meeting of the Society that nobody should have the temerity to become an engineer unless he could make freehand perspective engineering drawings. That test would eliminate many engineers today! Sisson himself had marked ability in that field.

Mr. Chas. E. Lee said that he well remembered the Belliss steam bus from his school days when some exhaustive tests were made in the Edgware Road in 1908. There are references to it in *Motor Traction*, 17 October 1908, and *Commercial Motor*, 7 May and 16 July 1908. He was surprised to hear that it had a Clarkson boiler, because it was used in competition with the Clarkson bus at the time when Clarkson was making his own Chelmsford steam vehicle and, as far as Mr. Lee was aware, was not supplying parts to anybody else. He would like confirmation that it did have a Clarkson boiler. Mr. Lee gave further information on the vehicle: it was licensed to the London General Onmibus Company on test on 17 December 1907 and continued to run for about a year largely through the activities of Frank Searle. Searle was at that time Chief Engineer of the London General Omnibus Company and was a keen supporter of steam as against the petrol engine which was then much favoured. It was only by Searle's efforts that steam got a chance. Would Mr. Belliss agree that one of the drawbacks of the Belliss car was the great weight of the steam chassis? When licensed, the unladen weight was given as 4 tons 15 cwt. 3 qr. This included a 30 h.p. steam engine, very much heavier than the corresponding petrol engine of the period. The steam bus was a 34-seater (16 inside, 18 outside). Subsequently, after the L.G.O. Co. had ceased to be interested in steam and had over-ruled Frank Searle, Clarkson designed his own National vehicle; the first of these was licensed at a weight of 3 tons 9 cwt. 2 qr. This very considerable saving in weight gave steam a further lease of life, and in fact steam buses ran successfully in London until 18 November 1918.

The Belliss steam bus was first placed in service on a route in London between Hammersmith and Canning Town (an east-west route). In May 1908 it was transferred to the Acton and Bow Bridge route. In September 1908 it was transferred to the Victoria-Cricklewood route to run in competition in comparable conditions with a newly-designed lighter bus with a De Dion chassis and a Clarkson boiler. The fate of the Belliss & Morcom vehicle after the trial was unknown to Mr. Lee.

Mr. H. Holcroft said that his first visit to an electricity generating station was made about 1898, and there large steam engines, running at quite a moderate speed, drove generators at high rev. per minute through multiple-rope drive. Five years later he saw a revolution in practice. The Exhibition of 1902 at Wolverhampton covered a large area of ground with many pavilions that needed lighting and power for operating machinery. This was provided by generating sets in the Hall of Engineering, all of the high-speed vertical type (with enclosed crankcase) directly coupled to multi-pole generators for D.C. 440/220 volts on the three-wire system. All these sets were in a row so that it was possible to make direct comparison between the designs of several makers. His preference was for the Belliss, and ever since he had taken an interest in its further development.

In a paper read before the Institution of Electrical Engineers, Alfred Morcom published some data relating to the enclosed force-lubricated engine. He gave the mechanical efficiency at full load as being 96·3 per cent. and at half load 94·4, and there was an entire absence of knock, a great advance.

At this period the large gas engine such as those made by Crossley or Tangye was of the horizontal single-cylinder type with two heavy flywheels, and with hit-and-miss governing. These prime movers were quite satisfactory for driving main shafting of shops through belts, or for pumping plant, but unsuitable for electricity generation, having no more than one power stroke in two revolutions, and sometimes missing that through the method of governing. In the course of the next 10 years or so development of the gas engine took place, resulting in a vertical four-cylinder power unit with enclosed crank case, so resembling the steam engine in appearance. It had two power strokes per

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revolution and was governed by throttle. Such power units could run cheaply on waste gases containing carbon monoxide, or from producer gas generated from waste carbonaceous matter. It became a serious competitor to the steam engine, and the author states that Belliss & Morcom proceeded with the design of such a gas engine, but that they abandoned it after a time on account of revived demand for steam engines.

This revival was no doubt due to the adoption of superheating. In a paper read before the Institution of Electrical Engineers in 1904 Alfred Morcom showed a diagram on which pounds of steam per horse power hour were plotted against temperature of steam. There was a sharp drop in steam consumption until a rise in temperature of 50° F. above that of saturated steam was reached, when the graph curved and then began to flatten out, further superheating having less effect. This shape of curve not only applied to full loads but also to half loads. The explanation given was that, while there was a thermo-dynamic gain throughout, leakage of steam past pistons and valves markedly increased when the superheated steam began to assume the characteristics of a permanent gas.

For cylinder lubrication in earlier times and with saturated steam all that was needed was a little tallow. When that became more expensive a mineral oil blended with a small proportion of oil derived from vegetable or animal sources was adopted, as with wet steam it could form an emulsion that clung to the surfaces of sliding parts. With superheating a straight mineral oil had to be used, but this did not cling to the surfaces in the same way; it had to be evenly distributed by some other means.

After the 1914–18 war came the decision to set up the Grid to distribute electricity, covering the whole country. This knocked out further plans of municipal authorities and private companies for the erection of individual power stations. Belliss & Morcom turned their activities to other fields, notably towards manufactures that required a large volume of low-pressure steam for processing. By interposing their high-speed steam engine between high-pressure boilers and low-pressure mains power could be generated very cheaply. Another development lay in their designs of air-compressors of various types. In some cases air must be delivered free of any trace of oil; this also applies to process steam. How does Belliss & Morcom overcome this problem; do they, for instance, use graphited carbon rings and packings?

Mr. A. THROP said that in the early 1920s he spent a good deal of time in South Wales on the erection of condensers working with turbines and engines. Belliss engines were at that time very common in the collieries; some were well cared for, some grossly neglected, but all continued running, due to the excellent workmanship that had been put into them. Forty years ago he was working at Abercarn Colliery near Newport where a three-crank triple expansion engine (700 or 800 h.p.) was running the colliery ventilation plant. During the time he was there this engine had been running night and day for 10 months and had never had the stop valve shut. Mr. Throp said he had a very great respect for the products of Belliss & Morcom, all of whose staff must have been first-class engineers.

Mr. Throp asked what was the relationship of Mr. Belliss to the G. E. Belliss in the village of Roden in Shropshire.

Mr. N. D. NEW asked if, in the engines running a generator or compressor, the shafts were rigidly joined together, or were they universally jointed and, if the latter, did they suffer fatigue and have fractures in that region in consequence of their alignment?

Replying to the speakers Mr. J. EDWARD BELLISS said there was no connection between the Belliss & Seekings locomotive engine and any other as far as is known. He had not succeeded so far in finding any family connection with other Bachs. William Sisson was a very good naval architect and that was probably where he got a good deal of his ability to sketch freehand. The launches on the Thames

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which follow the Boat Race every year were designed by Sisson, the boat as well as the engine; so were many other launches on the Thames.

The Belliss & Morcom bus did have a Clarkson boiler, which astonished him, knowing that Clarkson also built that type of vehicle. Mr. Belliss's guess was that Belliss knew it was the best type of boiler available for the job and determined to have it to enhance the firm's already considerable reputation; but how they got round Clarkson is not known. He agreed with Mr. Lee that no doubt the weight of the steam-driven bus told against it; the heavy weight on solid tyres could do a lot of damage to the road, and no doubt did.

The introduction of superheat was probably one of the reasons for the revival of the popularity of the steam engine, for superheat did make it a more economical machine to run. But it did produce complications in the lubrication of the piston valve and cylinder. At temperatures up to about 700° F. a straight mineral oil will stand up to most of what is required of it. Others did try graphite or graphite compounds for lubrication in these circumstances, but Belliss always found the straight mineral oil best.

The lubrication of cylinders interested the Company considerably. About 1910 they introduced the use of phosphor bronze for piston rings and were then able to run a steam engine with dry saturated steam without oil lubrication in the cylinders. This produced clean exhaust steam. Thousands of engines were built in this way. The present means of running an air compressor without lubrication in the cylinders is by using carbon piston rings and carbon packing for the piston rods which is quite successful up to pressures of about 150 lb./sq. in.

A propos of Mr. Throp's remarks, Mr. Belliss said that of course colliery fan engines could not be stopped, otherwise all the men had to be fetched out of the pit. It was a common thing for steam engines to be used for this purpose with no standby; the only time they were shut down was during the long holiday and then only for two days; otherwise it would probably take a fortnight to defoul the pit before men could go down again. It is on record that a triple-expansion Belliss engine driving a water pump in Calcutta ran without stopping for three-and-a-half years and was the only source of pumped water to Calcutta during that time.

Replying to Mr. New, Mr. Belliss said that all shafts were rigidly coupled together. The coupling between the driving and the driven unit was bolted up solid. There were a few broken shafts but not from bad alignment; usually the effect of some sort of seizure.

In reply to a question by the PRESIDENT, Mr. Belliss said that Belliss & Morcom were still making steam engines, mostly for the combined purposes of generating electric power for industrial use and providing the exhaust steam for process work. Sisson's were making engines up to about 150 kw. and Belliss & Morcom anything up to 1,000 Kw. In addition, Sisson's were also making the "instructional" engine used in colleges and universities.

Mr. Belliss said that he was a great-nephew of George Edward Belliss who had two daughters but no sons. He brought three nephews into the business, all of whom became directors of the Company in due course and played a considerable part in the Company's fortunes from about 1884. One of these was Mr. Belliss's father who died in 1938.

CORRESPONDENCE

Mr. H. J. HETHERINGTON wrote:

The enclosed, forced-lubricated engines manufactured by Belliss & Morcom Ltd. were excellent, being silent and capable of prolonged trouble-free periods of running. One of these machines was fitted at the workshops of the Union Castle Royal Mail Steamship Company at Blackwall, E.14, where I served my apprenticeship. It drove the fitting-shop machinery via pulley and belt at one end of a shaft, the other end being coupled to a dynamo that provided power for the joiners' shop, etc. It gave

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no trouble at all and was only replaced by an electric motor to give cheaper running costs as it was then possible to dispense with the boiler. Similar engines were used in the S.S. *Prince Arthur* and *Prince George* requisitioned by the Admiralty and run by the Union Castle Line during the 1914–18 war. There were two per vessel driving dynamos. Perhaps Mr. Belliss could give some particulars of these three engines. It was found necessary to clean out the oil system as emulsion formed with condensed steam. This trouble was overcome by using turbine oil in place of the compound oil normally used with hand-lubricated machinery.

The wooden torpedo boats to which Mr. Belliss refers were carried by capital ships and were known as second-class torpedo boats. The first-class torpedo boats were built of steel and capable of operating independently. The torpedo gunboat or torpedo boat "catcher" was developed as an answer to these, but when the torpedo boat was improved so as to be faster than the "catcher" the torpedo boat "destroyer" was introduced. The first destroyer was, I believe, H.M.S. *Havock* built by Yarrow in 1893.

Mr. Hetherington wrote later to say that in *The Engineer* for 1889, Vols. 67 and 68, he came across an account of a vessel described as a "torpedo gunboat or *torpedo boat destroyer*." It would appear that the name of T.B. destroyer was originally applied to these "catchers" and that most works of reference are not strictly accurate in calling H.M.S. *Havock* the "first" T.B.D. although she was undoubtedly the forerunner of the highly successful type or class of vessel that we now know as a T.B. destroyer.

In reply to Mr. H. J. Hetherington's letter, the Author wrote:

Without reference to the works I am not able to give any particulars of the engines used by Union Castle but I am sure there was nothing extraordinary about them.

I have come across some more information on the twin-screw gunboats engined by G. E. Belliss & Co. They were *Sharpshooter*, *Spanker*, *Swordfish* and *Spitfire* for the British Navy, and *Boomerang* and *Karrakatta* for the Australian Navy.

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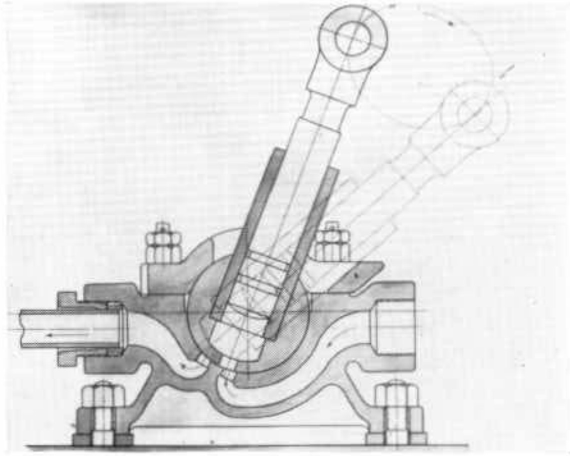
PLATE III



Top left: premises in Broad Street, Islington, Birmingham: Works of Richard and Francis Bach (1852)

Bottom left: Belliss and Seekings: advertisement of steam engine

Bottom right: Belliss and Seekings: advertisement of locomotive

Top right: Belliss valveless oil pump

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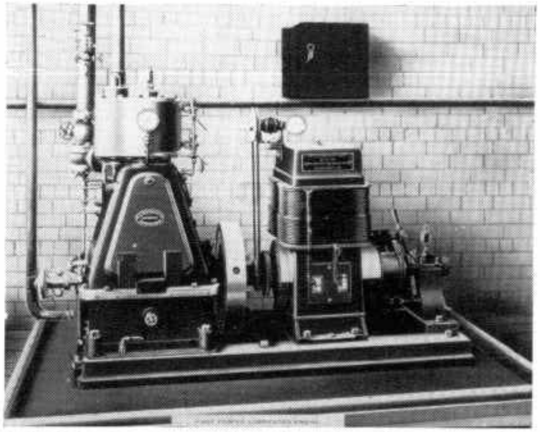
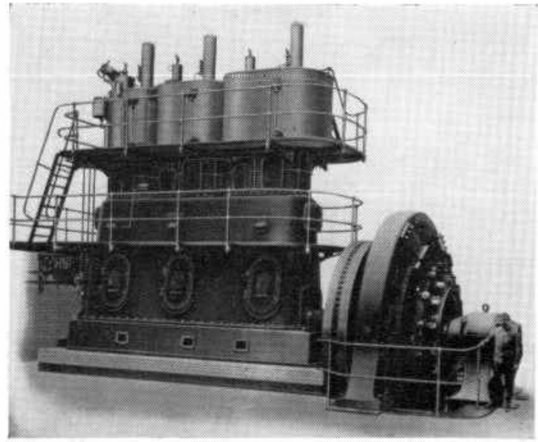
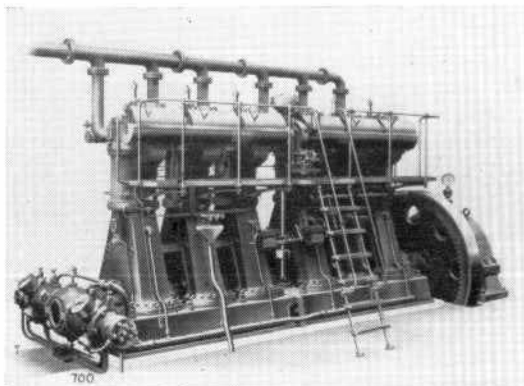


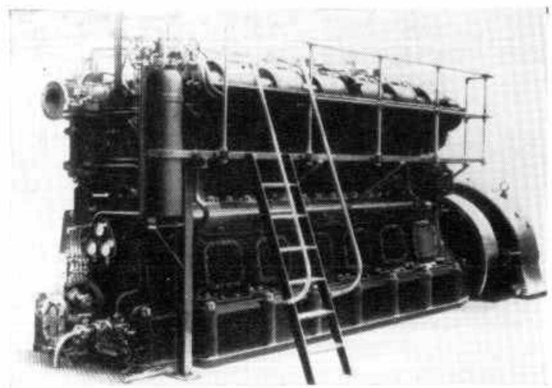
(*a*) No. 1 enclosed force-lubricated steam engine



(*b*) 1500 K.W. triple-expansion steam engine



(*c*) Open A frame air-injection disesel engine



(*d*) First enclosed air-injection diesel engine

Belliss steam and diesel engines

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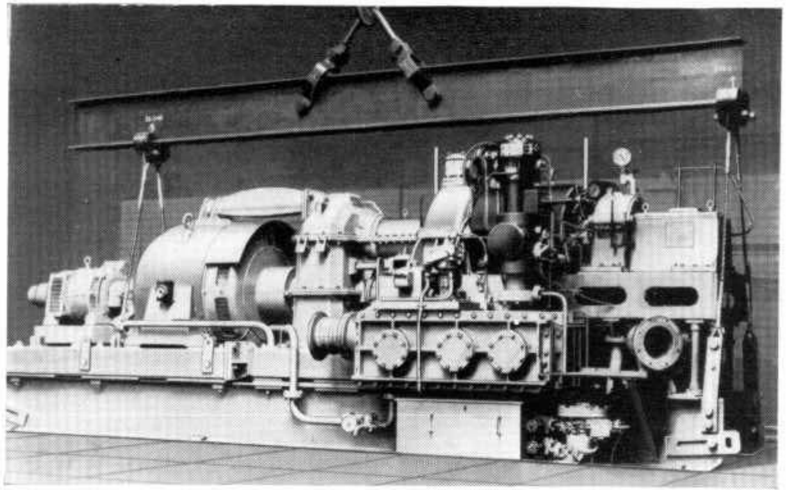
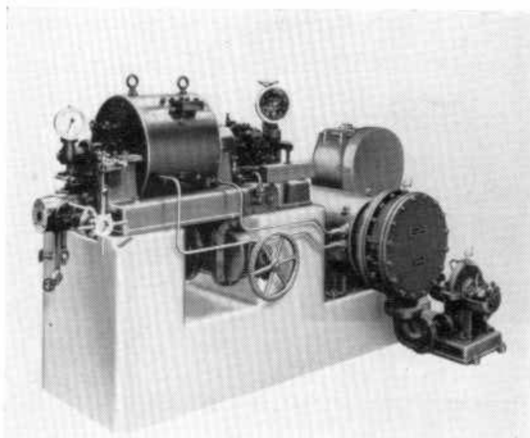
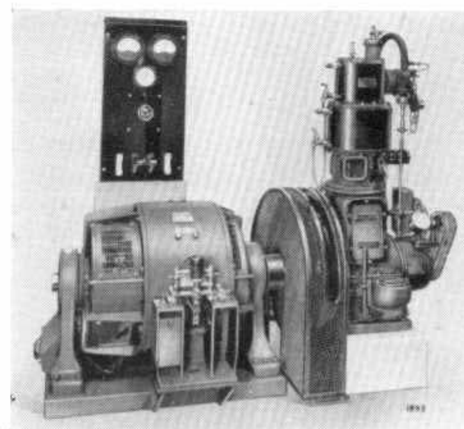


(*a*) Self-contained transportable turbine alternator set



(*b*) Instructional turbine and condenser set



(*c*) Instructional steam-engine set

Belliss turbine alternator and instructional sets

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